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TECHNICAL REPORT
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TECHNICAL OBJECTIVE DOCUMENT FOR AIRDROP SYSTEMS

BY

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FINAL REPORT
JULY 1988 TO NOVEMBER 1988

UNITED STATES ARMY NATICK
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AERO-MECHANICAL ENGINEERING DIRECTORATE
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This document provides information on the Army's technical objectives for the Airdrop Systems areas to the external community, both Government and nongovernment, including academic, scientific, and industrial organizations. The purpose is to stimulate the participation of such organizations in Army research and development. Areas include:

- Management Review
- Technology Base Investment Strategy
- Technical Objectives
- Progress and Accomplishments
- Planned Programs (Research, Technology and Development)
- Major Technological Barriers
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SUMMARY

This document provides information on the Army's technical objectives for the Airdrop Systems areas to the external community, both Government and nongovernment, including academic, scientific, and industrial organizations. The purpose is to stimulate the participation of such organizations in Army research and development. Areas include:

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TECHNICAL OBJECTIVE DOCUMENT FOR AIRDROP SYSTEMS

I. INTRODUCTION

The U.S. Technical Objective Document is an important part of the Army's Information for Industry Program. Each Army laboratory and research, development and engineering center has an opportunity annually to prepare a Technical Objective Document based upon Army requirements, scientific and technological opportunities, and the needs of present and projected systems.

We all recognize that the developments and accomplishments of the Army are the product of teamwork among Army scientists and engineers and their counterparts in industry and the academic community. This document is intended to increase this teamwork by providing you with necessary information on Natick's research, development and acquisition program. Specific objectives are:

To provide planning information for independent research and development programs.

To improve the quality of unsolicited proposals and R&D procurements.

To encourage face-to-face discussions between Army engineers and scientists and their external counterparts.

As you read through the pages that follow, you may see an opportunity to which your organization can respond. We invite you to discuss the opportunity with the scientist or engineer identified by name. Furthermore, you may have completely new ideas not considered in this document, which, if brought to the attention of the proper organization, could make a significant contribution to the Army's capabilities. The Army has a continuing interest in receiving proposals that contain new ideas, suggestions and innovative concepts for weapons, supplies, facilities, devices and equipment. In other words, your ideas, whether in response to this document or not, are always welcome.

Classified/limited distribution Technical Objective Documents are available from the Defense Technical Information Center, Alexandria VA, 22304-6145 while unclassified/unlimited documents are available from the National Technical Information Service, Springfield, VA 22161. These documents, as well as additional information on doing business with the Army, are also available from the Army's Technical Industrial Liaison Offices.

II. MANAGEMENT OVERVIEW: U.S. ARMY NATICK RD&E CENTER

1. MISSION

The mission of the U.S. Army Natick Research, Development and Engineering Center (Natick) is to ensure maximum survivability, supportability, sustainability and combat effectiveness of individual soldiers and crews on the battlefield under worldwide environmental extremes.

Our goal is to provide the American soldier the best equipment for the best price through research, development, and engineering in the areas of Airdrop Systems, Food and Food Service Systems, Tactical Shelters, and Clothing and Individual Equipment. We are deeply committed to making our soldiers, and all Service members, the best equipped and best fed in the world.

2. ORGANIZATIONAL STRUCTURE

Natick is an element of the U.S. Army Troop Support Command (TROSCOM), a major subordinate command of the U.S. Army Materiel Command (AMC). Natick is currently organized with three commodity-oriented directorates - the Individual Protection Directorate (IPD), the Food Engineering Directorate (FED), and the Aero-Mechanical Engineering Directorate (AMED); three technical support directorates--the Advanced Systems Concepts Directorate (ASCD), the Science and Advanced Technology Directorate (SATD), and the Engineering Programs Management Directorate (EPMD); and requisite administrative support elements.

Our commodity directorates are responsible for planning, organizing, and conducting/overseeing all required research, development, and engineering in their assigned areas. AMED performs these functions for airdrop systems and also coordinates all Army contributing RD&E efforts concerned with the airdrop of military personnel and cargo.

3. PROGRAM AREAS

Natick's programs encompass the total spectrum of research, exploratory, advanced and full-scale engineering development and the operations and maintenance activities essential for standardization and production engineering in support of procurement.

Our efforts are focused primarily on three commodity areas and include several distinct fields of endeavor, all covered by the AMC/TRADOC Combat Service Support Mission Area Material Plan (CSS MAMP). They are:

AIRDROP AND COMBAT SERVICE SUPPORT

- Advanced Personnel and Cargo Airdrop Systems
- Hardened Shelter Systems
- Tentage and Organizational Equipment Systems

COMBAT CLOTHING AND INDIVIDUAL EQUIPMENT	- Lightening the Soldier's Load - Ballistic Protection - NBC Protection - Countersurveillance/Flame/DEW Protection - Environmental Protective Clothing - Microclimate Conditioning Equipment
FOOD ENGINEERING AND FOOD SERVICE EQUIPMENT	- Combat Feeding Systems - Operational Rations - Ration Packaging Systems

Our overall program is planned and prioritized in response to the deficiencies in the Training and Doctrine Command Battlefield Development Plan and is fully coordinated with the user. Its execution is effectively managed using a modern management control system to ensure that the individual soldier's needs are accurately identified and expeditiously addressed.

4. PROGRAM GOALS

Our program goals are to:

Ensure maximum survivability, supportability, sustainability and combat effectiveness of individual soldiers and crews at all times under all environmental conditions.

Be the Center of Excellence for research, development and engineering in combat rations and food service systems, combat clothing and individual protective equipment, tactical shelters and tentage, airdrop systems and organizational equipment.

Achieve major technological and system improvements on highest priority user-relevant programs and expedite fielding of these improvements.

Exploit the worldwide technology base to achieve mission technology superiority.

Plan and conduct technology base programs which support development of Natick's Next Generation/Notional Systems (NG/NS) by addressing major technology barriers.

Optimize the use of resources to enhance productivity.

Maintain a cohesive long-range R&D plan and a corporate strategy which achieve and sustain mission superiority.

III. TECHNOLOGY BASE INVESTMENT STRATEGY

Technology is the lifeblood of new and improved Army systems and equipment. However, technology can only be an effective force multiplier if the application is fielded quickly. Streamlined acquisition measures are used by Natick to shorten the time between proving a concept feasible and putting a system in the hands of the troops.

Exploiting new technologies to field affordable systems and equipment for the Army is a challenging process, one that is becoming institutionalized at both AMC and TRADOC through comprehensive analysis and long-range planning. The Army's Long-Range Research, Development, and Acquisition Plan (LRRDAP), TRADOC Mission Area Development Plan (MADP) and AMC/TRADOC Mission Area Materiel Plan (MAMP) provide the means for articulating a strategy for overcoming battlefield deficiencies and a rational allocation of resources based on criticality of need. The link between mission area strategies and technology base planning is a set of Next Generation and Notional Systems (NG/NS). Next Generation Systems are those immediately beyond those currently in development, and Notional Systems are those in the extended time frame designed to meet Army needs in the year 2000 and beyond.

Natick is the proponent for several NG/NS, including one airdrop Notional System entitled "Advanced Aerial Insertion System 2000" which is described in the Appendix. NG/NS are generally described in conceptual terms and provide a set of references and targets for technology base efforts needed by focusing on specific critical technological barriers.

Natick's technology base investment strategy is composed of four major elements:

1. NEXT GENERATION AND NOTIONAL SYSTEMS

Approximately 25 percent of our technology base resources (6.1 basic research, 6.2 exploratory development, and 6.3A proof-of-principle technology demonstration) (Tech-Demo) are currently allocated in support of specific Next Generation and Notional Systems (NG/NS). Next Generation Systems are the systems that will begin full scale development in the 1990s and will provide a fielded capability into the 21st century. Notional Systems are capabilities that would potentially be developed in the early 21st century. For each system, the technological barriers have been identified which could prevent achievement of the capabilities desired. Programs and proof-of-principle demonstrations of prototypes (tech demos) have been structured in a logical, time-phased manner.

2. EMERGING TECHNOLOGIES

The potential of some emerging technologies is so great that it warrants special visibility and management attention even when the application to a specific system is unclear. About 40 percent of the Natick technology base's total

resources is dedicated to maturing such high-payoff technologies. In the airdrop area, our key emerging technologies fall into the areas of flexible fabric wings, airbag and retrorocket cushioning systems, and the use of composite materials for airdrop components. In addition, there is a concerted effort, ongoing, in the area of biotechnology with emphasis on developing new and improved fibers.

3. CHRONIC PROBLEMS

Chronic problems that face the airdrop system user, such as labor intensive rigging, dispersion reduction, and the performance of clustered parachutes, lend themselves to technological solutions, but often do not have a system focus. About 20 percent of our technology base resources is allocated for these kinds of problems to make sure they get the attention they require.

4. SUPPORTING CAPABILITIES

Finally, our investment strategy allocates about 15 percent of resources in support of analytic capabilities. These include front-end analyses (analysis of airdrop support in Army 21 operations), modeling and simulations (e.g., scale modeling of parachutes to analyze steady state and dynamic performance), ADP data base development(e.g., anthropmetric survey including follow-on programs), special purpose equipment, and other infrastructure items that ensure our continuing ability to execute quality R&D programs and act as smart buyers across the entire spectrum of the material life cycle.

IV. AIRDROP SYSTEMS

1. OVERVIEW

Natick's Airdrop Systems technology program is directed toward achievement of broad objectives that either improve product/systems performance, or that create totally new airdrop capabilities. The technology program supports an increasingly wide spectrum of airdrop operations or requirements to meet the challenges of tomorrow's battlefield.

The overall objectives include:

- increasing the mass of delivered supplies and equipment;
- reducing drop zone dispersion;
- accelerating assembly time on the drop zone;
- increasing the reliability of airdrop systems;
- reducing the logistics burden within the support system;
- reducing the labor intensity of rigging and packing operations;
- reducing the vulnerability of delivery aircraft;
- reducing the vulnerability (and injury) of airborne personnel using these systems.

Airdrop Systems technology seeks to achieve these objectives by applying state-of-the-art techniques, methodologies, and materials to the RDTE process. By exploring the viability of new materials, such as structural composites, Natick is taking emerging technology and applying it to chronic airdrop problems. Natick's approach to the RDTE process is varied and dynamic. We are currently investigating new concepts for clustered parachutes, and are testing flex-wing technology for offset deliveries. We are actively examining low altitude, high speed deliveries to reduce aircraft, personnel and cargo vulnerabilities, and are developing an analytic capability for testing, data collection, experimental correlation, and computer simulation. The resultant payoffs include safer deployments and deliveries, cost reductions, time/labor savings, and improved equipment performance and reliability.

Applied research efforts in the Airdrop Systems area have been conducted in a group of separate technology areas supporting Airdrop Systems development. Research efforts in this area are largely focused on modernizing the current personnel, heavy-drop, and resupply systems to overcome known airdrop-related deficiencies through improvements or system developments. In some instances, the technology emerging in one area serves to support another. For example, the use of flex-wing canopies in personnel systems provided an initial performance data base upon which experimental cargo systems could be conceptualized and developed; composite materials are now being examined for use in heavy drop components as well as in experimental components in high altitude personnel systems to reduce opening forces. In short, the development of Airdrop Systems to meet the requirements of Army 21 and to meet the objectives of the current research and development program is the technological challenge for the next decade. The Airdrop Systems technology areas include:

a. Soft Landing Airdrop Technology

b. Flexible Fabric Wing Technology

c. Parachute Technology

d. Rigging Technology for Airdrop Systems

e. High Speed Airdrop Technology

f. Advanced Concepts/Designs

2. TECHNICAL OBJECTIVES

Our technical objectives in the Airdrop Systems area include:

a. <u>Near Term (current to five years):</u>

Development of advanced personnel recovery (high-speed) systems. (Major Thrust)

Development of components for improved cargo delivery. (Major Thrust)

Development of Low Altitude 2.5K to 60K pounds Retrorocket Airdrop System (Major Thrust)

Exploration of structural composite applications to reduce weight and life cycle costs for parachute components and advanced airdrop systems.

Improvement of parachute glide ratio (increasing lift/drag) to enhance the capability for the offset infiltration/delivery of parachutists or cargo through the continued development of flexible fabric wings.

Improvement of parachute deployment and descent characteristics to increase payloads and delivery speeds while lowering drop altitudes. Objectives include continued development of annular parachutes for this purpose.

Reduction in the costs of associated logistics by examining the use of square parachutes, alternative energy absorption systems, and other options.

Development of capability for high speed heavy cargo delivery using a single canopy design for deployment at 250 knots airspeed to minimize aircraft vulnerability. Clustered deployments to follow single canopy tests. Concurrent development of high speed personnel systems.

Development of soft landing capability of airdropped cargoes by parachutes and airbags from low altitude and at high speed. This includes platform drive on/drive off capability for loads up to 60,000 pounds delivered from 300 feet altitude at 250 knots airspeed.

Development of methodology and design parameters for equipment necessary to provide an enhanced rigging capability for the airborne division. This technology will serve to simplify rigging procedures, provide remote site rigging capability, improve response time and planning, and reduce the overall logistics burden.

Provision of timely and effective support to:

Special Operations Forces (SOF)
The airborne division and units in support of its airdrop mission
Other Army air delivery units
Army Test Beds (ATB) and other specialized program requirements

Development of advanced parachute release and harness for use in conjunction with low altitude airdrops.

Development of an enhanced container delivery system to resupply bulk rations, ammunition and fuel.

Development of drop zone assembly aids to speed and improve the systematic evacuation of the drop zone.

b. Mid-Term (5 to 10 years):

Continue tech base efforts in the areas of soft landing and capsule design for the NG/NS Advanced Aerial Insertion System 2000.

Begin full scale engineering development of Low Altitude Retrorocket System (LARRS).

Complete development of 250 knot high speed personnel parachute, linked platform extractions and complete improvement of clustered canopy performance.

Successful demonstration of the major components of the Advanced Aerial Insertion System 2000.

Integration of developments with experimental Air Force aircraft.

c. Long-Term (10 to 20 years):

Completion of advanced development and successful transition of the NG/NS for all identified AAIS 2000 systems - Army 21 objectives fully supported through type classification of NG/NS - reduction of labor intensive rigging operations - and continue automation of information systems relating to rigging operations.

3. PROGRESS AND ACCOMPLISHMENTS

Natick is responsible for many RDTE programs. Military relevance, quality products, mission productivity, progressive management initiatives, and technical competence are synonymous with our programs, our staff, and our achievements. Through engineering for today, development for tomorrow, and research for the future, we are truly providing the decisive edge for the American soldier. We have, for example, focused our tech base programs toward the technologies needed for NG/NS, while still addressing the chronic Army problems, emerging technologies, and required supporting capabilities. Examples of recent accomplishments in the Airdrop Systems area follow.

a. Research Program (6.1): During FY 88, our research program accomplishments included:

Completed development of the solution procedure for flow over decelerator in motion, and, using this procedure, investigated the terminal velocity, added mass, and drag performance of decelerators.

Developed both the mathematical model and the computational tools needed to understand the initial opening phase of canopies.

b. Technology Program (6.2): During FY88, our technology program accomplishments included:

CLUSTERED PARACHUTES: Conducted tests of connected G-12 cargo parachutes to examine the shock distribution problem associated with the opening of clustered parachutes. The goal of the tests was to obtain evenly distributed opening shocks through simultaneous openings of three clustered/connected G-12 parachutes, which were deployed from one common D-bag. The results showed improvement over standard (nonconnected) clustered G-12 parachutes.

ANNULAR PARACHUTES: Conducted tests of four annular parachute models each having a different porosity but identical canopy. The objective was to optimize the drag coefficient by varying material porosity. Results demonstrated that material porosities affected the rates of descent. Continued testing will focus on the geometric porosity of the annular parachutes.

FLEX WING: Tested optimized flex wing for 2200 pound payload and modified design. Nine staged deployments were conducted of the optimized flex wing. The bulk of these staged deployments, which used the G-12 as the first stage, were successfully completed. The overall goal (after proof-of-deployment-principle) is improvement of the flex wing glide slope.

SQUARE DRAG PARACHUTE: Completed exploratory testing of a parachute having a square platform. Opening and descent performance were compared with the performance of circular canopies under identical conditions in a wind tunnel and in free descent. With the addition of an inverted cone below the skirt, the square canopy demonstrated 67% lower opening shock and significantly better stability.

250 KNOT CARGO PARACHUTE: Completed the design of 70-foot diameter ring-slot, solid cloth cargo parachute for high speed delivery of loads up to 7,500 pounds. The design permits the early release of the extreme pressures experienced during high speed openings. The parachute can be clustered up to three parachutes per delivery.

COMPOSITE MATERIALS AND AIRDROP COMPONENTS: Performed stress analyses on small composite hardware items using computer studies. The focus of the evaluation was on the materials and shapes that could serve as alternates (or replacements) to the standard alloy "D" ring and other components. The evaluation identified the complexity of the components as significant cost

factors, representing a barrier to their development. In addition, studies were initiated to examine the use of composite materials (principally S-2 glass) in nonmodular platforms to reduce weights and lower costs.

AIRBAGS: Conducted tests and process modeling of the 4000 pound airbag system with controlled venting. Preliminary testing showed that impact force reduction can be achieved by controlling the rate (slowing the venting) at which the air escapes from the bags.

ALTERNATIVE ENERGY ABSORPTION: Tested foams as an alternative to paper honeycomb as a means of absorbing the impact energy of airdropped cargo loads. Conducted concept evaluations of pneumatic/hydraulic shock absorption systems to determine their utility for airdropped cargo loads. In addition, conducted similar concept evaluations of capstan spring devices.

ADVANCED PERSONNEL RECOVERY SYSTEM (APRS) - During FY88, Natick began development of a parachute recovery system allowing exits at a minimum altitude of 300 feet above ground level at 130-150 knots airspeed. Requirements included that the opening shock and oscillation be no greater than the conventional T-10B parachute, and that the rate of descent at 7000 feet mean sea level not exceed 22 feet per second. At the present time, two candidates are being considered: a 43-foot T-10, and a twin canopy parachute. Significant testing of both candidates was conducted to develop stability, oscillation, descent, and other performance data. This system is also known as the Personnel Air Infiltration Device (PAID), and is a follow-up to earlier research on low-altitude, high speed personnel systems.

c. <u>Development Program (6.3B and 6.4)</u>: During FY88, our development program accomplishments included:

RAM AIR PARACHUTE SYSTEM (RAPS) - RAPS is intended to provide Special Operational Forces (SOF) with a high-glide ram-air parachute system that will enable the clandestine infiltration of parachutists from jump altitudes up to 25,000 feet above mean sea level. The RAPS will provide a distinct lateral transverse and accuracy of landing capability that are not attainable with the present system. By use of this offset parachuting technique, aircraft and personnel vulnerabilities will be lessened. During FY88, tests were conducted at relatively low altitude to compare various reefing methods designed to reduce the chronic problem of opening shocks experienced during high altitude terminal velocity testing. Natick's initial position was to recommend limited type classification for RAPS during FY88 with weight and altitude restrictions at the upper end of the performance envelope. However, during FY88, Natick agreed to initiate side-by-side testing of foreign versus domestic parachute candidates to determine if a foreign candidate could satisfy the RAPS performance requirement. At the same time, Natick initiated a product improvement of the current RAPS candidate (MT1-XX) to attempt to satisfy the requirements without restriction.

PARACHUTISTS INDIVIDUAL EQUIPMENT RAPID RELEASE (PIER2) - Developmental efforts to design and field an improved H-harness with a single point release (SPR) for loads up to 120 pounds progressed rapidly during FY88. Form and fit

tests and design reviews were conducted, leading to the fabrication of a new prototype. The PIER2 will allow for the simultaneous release of the leg straps and the ALICE pack, and will be quick and simple to rig and de-rig. The simultaneous release feature will allow for airdrops to be conducted at a lower altitude.

ALL-PURPOSE WEAPONS AND EQUIPMENT CONTAINER (AIRPAC) - Current weapons and equipment containers and jump packs are inordinately heavy, bulky, and offer a limited range of use in view of emerging airdrop doctrine. The AIRPAC is a developmental all-purpose container system comprised of two containers, which can be employed together, separately, or in conjunction with the existing M-1950 weapons case to provide the parachutist's delivery of a wide variety of combat equipment, weapons, and missile systems. Progress during FY88 included form and fit tests, design reviews, and new prototype fabrications.

HIGH SPEED CONTAINER AIRDROP SYSTEM (HISAC) - This system is intended to provide a capability to air deliver up to 500 pounds of cargo (principally supplies and accompanying equipment) for Special Operations Forces (SOF) using very high speed U.S. Air Force tactical aircraft. The system contemplates the use of a specially designed, aerodynamically stable, container body design allowing for the employment of the system at speeds up to Mach 0.95 and a launch altitude of 200 to 300 feet above ground level. During FY88, one prototype system was assembled for testing. Vibration testing was conducted to analyze stability. Development will continue to examine alternate materials for the container body design to withstand aerodynamic heating at the higher speeds.

DROP ZONE ASSEMBLY AIDS (DZAAS) - A chronic operational problem facing airborne units is landing on or near the intended impact point, then efficiently assembling personnel and equipment after landing. The Drop Zone Assembly Aids System (DZAAS) uses electronic direction finding technology to rapidly assemble men and materiel by providing an electronic homing capability. The DZAAS is configured as a small transmitter with omni-directional signal antenna and an arm-worn receiver to pick up any one of a minimum of 25 signals without any directional ambiguity. The transmitter can be prepositioned on an equipment load, or can be carried by a designated jumper. Full competitive procurement was selected as an acquisition strategy during FY88.

AERIAL RESUPPLY AND ACCOMPANYING BUNDLE SYSTEM (ARABS) - ARABS is designed to give Special Operational Forces an airdrop system capable of high altitude offset delivery of up to 500 pounds of equipment and/or supplies. The system will be remote (radio) controlled, and will feature a high-glide ratio wing or ram-air parachute. In FY88, eight complete prototypes were delivered to the test site by the contractor, and testing was initiated by Natick. Evaluation will continue into FY89 to resolve the technical issues. Based on early results, ARABS appears to be a viable airdrop system that will enhance the operational capabilities of the SOF users, and minimize the vulnerabilities of the aircraft delivering it.

TANDEM PLATFORM LAPE - Current R&D in this area is concentrated on increasing the gross rigged weights for tandem platform low altitude parachute

extraction (LAPE) to deliver platforms with total weights up to 60,000 pounds. This will enable both the 42K and 60K LAPE Systems to deliver a greater diversity of payload types in a single aircraft pass over an extraction zone. During FY88, a Request for Proposal (RFP) was released by Natick for analysis, design and fabrication of tandem LAPES hardware to control linked airdrop platforms during LAPE operations. The tandem platform LAPE research and development will focus on loads up to 42K from C-130 aircraft, and loads up to 60K from C-17 aircraft. A series of technical feasibility tests will be conducted using the initial prototype hardware developed by the successful contractor.

4. PLANNED PROGRAM

With fiscal restraints, it is imperative that our research, technology, and development program efforts be prioritized to maximize our gains for the individual soldier. To that end, therefore, our planned programs for fiscal year 1989 will be focused on priority areas, and our major objectives include:

a. Research Program

(1) FY89 Planned Program

Make further refinements in the porosity model for use in the study of decelerator behavior using computational fluid dynamics.

Investigate dynamic behavior of low dimensional model of canopy during initial opening phase.

FOCAL POINT FOR RESEARCH PROGRAM: John M. Calligeros
Telephone 508-651-4267

b. Technology Program

(1) FY89 Planned Programs

Complete clustered G-12 parachute tests to evaluate performance of the connected parachutes. Continued positive results would tend to support proof-of-principle relating to simultaneous deployment.

Refine the performance of annular parachutes and the flex wing to develop performance data regarding geometric porosities and increased glide ratios, and then to conduct full scale evaluations.

Conduct 250 knot parachute tests at Yuma Proving Ground using newly designed and fabricated high speed candidate.

Examine scaling effects of canopy material properties. The objective is to determine the performance of these materials when used in scaled applications.

Conduct trade-off studies of composite platform concepts to examine material strengths, costs, complexities, and concept viability.

Complete 4000-pound payload airbag tests with controlled venting to evaluate impact force reduction using this technology.

Conduct studies to:

- examine concepts to accelerate the parachute opening process;
- examine new ribbon parachute construction, improved articulated dummy and self-reefing techniques;
- examine computerized rigging procedures, NG/NS, Chemical/Biological protection, and alternative energy absorption concepts.

Evaluate strain and pressure measurement techniques in live tests.

(2) FY90 Planned Programs

Conduct direct deployment tests of flex wing

Conduct model test of canopy material scaling

Construct prototype composite material platform

Conduct model tests for accelerated parachute opening

Conduct tests of ribbon parachute, verify performance and strength

Fabricate prototype of improved articulated dummy

Initiate study of nonlinear fabric behavior under dynamic loads

Continue systems analysis of rigging procedures

FOCAL POINT FOR TECHNOLOGY PROGRAM: Mr. John M. Calligeros
Telephone: 508-651-4267

c. Development Program

(1) FY89 Planned Program (Advanced and Engineering Development)

Conduct testing of Heavy Drop Derigging/Quick Release Tiedown System. In house testing was previously conducted using fabricated drive-off aids on 2-1/2 ton and 5-ton vehicles. User/customer tests will be conducted in FY89 to enhance drive-off/derigging at the drop zone.

Complete the advanced development of the Enhanced Container Delivery System and Low Altitude Container Delivery System for C-17 aircraft.

Conduct advanced development phase flight tests of 60,000 pounds capacity Linked Platform System. The 60K Linked Platform Systems will use a low-velocity airdrop (LVAD) or a LAPES configuration for delivery. The LVAD mode will use a cluster of 6 newly developed 137-foot recovery parachutes; the LAPES mode will use two or three modified USAF braking parachutes. FY89 development will include feasibility of using 42K Airdrop Controlled Exit System (ACES) components with 60K loads.

Conduct developmental testing of Drop Zone Assembly Aid System (DZAAS). The prototype system should be delivered in FY89 by the contractor.

Continue development of the Advanced Personnel Recovery System (APRS) by testing and collecting data relating to the candidate parachute (canopy) systems.

Continue support of the USAF C-17 aircraft development program by conducting engineering development required to certify Army equipment for airland and airdrop using this aircraft. Prototype airdrop systems will be identified for acquisition and test planning.

Complete testing of modified MT1-XX RAPS system, conduct in process review to determine ability of system (with product improvements) to meet performance requirements at gross weight and high altitude. Complete side-by-side testing of foreign and domestic RAPS candidates.

Initiate design and fabricate prototypes through contractual effort for low-altitude retro-rocket system (LARRS) capable of decelerating loads weighing from 2,500 pounds to 60,000 pounds to an impact velocity not to exceed 8 feet per second. During FY89, Natick will develop breadboard 20K systems.

Complete development of Parachutists Individual Equipment Rapid Release (PIER2).

Complete investigation of age/shelf life of parachutes. Investigation will predict service limits at various performance criteria to determine the cycle fatigue lifetime of the suspension line system.

(2) FY90 Planned Program

Type Classify Ram Air Parachute System (RAPS) candidate;

Complete advanced development of Advanced Personnel Recovery System.

Initiate tech demo task for Next Generation/Notional System Advanced Aerial Insertion System 2000, with in-house design and fabrication of system concepts for a 500 foot/250 knot personnel airdrop system.

Increase payload weights for Low Altitude Retrorocket System (LARRS) to 60K pounds.

Full scale development of High Speed Airdrop Container System (HISAC).

Provide prototypes for developmental airdrop items for C-17 aircraft.

Complete development of All-Purpose Weapons and Equipment Container System (AIRPAC).

FOCAL POINTS FOR DEVELOPMENT PROGRAM:

1. Mr. Robert Rodier
   Telephone Number: 508-651-4738
   For Parachute Systems, Generally

2. Mr. George Chakoian
   Telephone Number: 508-651-4106
   For Delivery Systems, Generally

5. MAJOR TECHNOLOGICAL BARRIERS

The major technological barriers that must be overcome to achieve near to mid-term Airdrop Systems Program objectives include:

a. SOFT LANDINGS: A soft landing capability of airdropped cargoes from low altitude and at high speed is essential to simplify de-rigging on the drop zone and allow for the drive-on/drive-off operation of airdropped motorized vehicles. Loads must be stabilized faster, decelerated quicker, and land softer than present systems allow. Airbag cushioning systems, retrorocket decelerator systems, or alternate energy absorption systems for use with improved cargo parachutes are needed to achieve soft landings. The complex dynamics of airbag systems present barriers relating to impact force reduction, drift landings, and aircraft extraction considerations. Major technological barriers involving retrorockets are the extraction, stabilization, and orientation of heavy (up to 60K pounds) loads from low altitudes, and the necessary retrorocket system component integration at these high cargo weights.

Technical POCs:

Airbag Cushioning Systems: Dr. Calvin K. Lee
Telephone: 508-651-5262

Retrorocket Systems: Henry E. Antkowiak
Telephone: 508-651-5275

Alternative Energy Absorption Systems: Alan Goldberg
Telephone: 508-651-5065

b. LOW-ALTITUDE, HIGH-SPEED PARACHUTES: Parachutes are needed that will allow for the high-speed, low-altitude delivery of personnel and cargo at combat ready weights. The technical barriers to be overcome include deployment system reliability, reliability of opening at low altitude, minimizing the opening shocks associated with high speed deliveries, and lowering the rate of descent to enable the parachutist or the cargo to land safely and accomplish the mission.

Technical POCs:

Personnel Systems: John Watkins
Telephone: 508-651-5282

Cargo Systems: Dr. Calvin K. Lee
Telephone: 508-651-5262

c. FLEXIBLE WING/OFFSET DELIVERY SYSTEMS: Personnel and cargo parachutes are needed that will give the capability to air deliver at high altitudes flying offset to the target area. The technical barriers include increasing lift to drag ratios to achieve the greatest possible lateral traverse capability; maintaining opening forces at gross weights and high altitudes within the range of human safety; improving the efficiency and reliability of onboard guidance and control systems for cargo wings, and the deployment characteristics of large wings.

Technical POCs:

Personnel Systems: Edward Giebutowski
Telephone: 508-651-5290

Cargo Systems: Robert Auer
Telephone: 508-651-4108

Wing Technology: James Sadeck
Telephone: 508-651-5263

d. COST AND LOGISTICS REDUCTIONS FOR PARACHUTES: Requirements exist for lightweight, low-cost, easy-to-pack, or inexpensive to maintain/repair parachute systems and components. Exploration is needed in the use of composites for component parts, and in the development of lightweight, high strength fabrics and metals for systems applications, and to increase shelf-life. Also needed are low cost systems for various applications.

Technical POCs:

Composite Materials: Walter J. Krainski
Telephone: 508-651-5264

Fabrics: Erwin Wuester
Telephone: 508-651-4257

e. DROP ZONE ASSEMBLY AIDS: The Army needs to reduce assembly times after airdrop operations by identifying assembly points and the location of equipment loads. Miniaturization (reducing size and weight), durability, reliability, radio frequency interference (RFI), and operational range of the equipment are technological barriers to be overcome in optimizing the electronic drop zone assembly aid system.

Technical POC:

George Laliberte
Telephone: 508-651-5278

f. INTEGRATED AUTOMATION IN RIGGING OPERATIONS: Improved techniques are needed to simplify the rigging of cargo loads and reduce manpower (labor-intensive) requirements. This need includes enhancing capabilities for remote site rigging outside the continental United States (OCONUS). Need exists for increased containerization of ammunition, fuels, and parachutes, and for the automation of operations at both the rigging site and at the drop zone. Development of portable materials handling equipment and robotic loading, unloading, parachute packing, honeycomb (or foam) cutting, and robotic palletizing operations is needed. The need also exists to improve inventory control and reporting relating to packing operations. Bar coding of parachutes is currently under consideration as means of inventory control and information automation. Technical barriers to be overcome are: the current limited range

of motion of robotics; the durability of bar-coding on frequently used parachute systems; and complexities of packing parachutes. Continuing analyses and concept research is needed in the areas of rigging operations, robotic applications, and shrink films for containerizing cargo loads in lieu of current systems.

Technical POC: Robert T. O'Brien
Telephone: 508-651-4670

The major technological barriers that must be overcome to achieve mid-to-long term Airdrop System Program objectives are indicated in the Appendix.

6. PROGRAM RELATIONSHIPS AND INTERACTIONS

a. Natick has significant interaction with other members of the Army Materiel Command (AMC) Research, Development, and Engineering community.

U.S. Army Chemical RD&E Center provides expert advice regarding Chemical Biological (CB) decontamination; methodology to assess the vulnerability/survivability of airdrop items on the CB battlefield, and test methodologies relating to CB.

U.S. Army Electronics Warfare/RSTA Center (CECOM) provides technical assistance relating to electronic guidance and control, direction finding equipment, and technical documentation for electronic component systems, such as the Drop Zone Assembly Aids System.

U.S. Army Aviation RD&E Center (AVSCOM) provides technical assistance relating to the airdrop of personnel and cargo from Army rotary-wing aircraft, and in personnel recovery/extraction systems, such as the Fast-Rope Insertion and Extraction System (FRIES). Natick has supported AVSCOM by furnishing assistance relating to aircraft ejection seat parachute systems.

U.S. Army Armament and Missile RD&E Center (MICOM) provides technical assistance regarding retrorockets systems and firing controls for retrorockets.

b. Natick also has extensive interaction with several U.S. Army Laboratory Command (LABCOM) laboratories in the airdrop systems area.

U.S. Army Laboratory Command (LABCOM) provides supporting technology, planning, and advanced concepts development for airdrop systems.

U.S. Army Human Engineering Laboratory on human factors in airdrop operations, including man/equipment interface and the physiology of personnel airdrop.

U.S. Army Materials Technology Laboratory on material technology, and modeling of materials, composites, and alternative energy absorption materials.

c. Natick also interacts with the U.S. Army Aeromedical Research Laboratory on human tolerance factors relating to the effects of altitudes, temperatures, pressures, oxygen levels, and gravitational (G) forces.

d. Natick interacts with other Services and government agencies to meet technology needs. Examples of these types of interactions are:

U.S. Naval Warfare Center on emergency rescue personnel parachutes, water activated parachute releases, textile materials, parachute shelf life, storage and repair, and the physiological responses to parachute opening shocks.

U.S. Naval Ordnance Station on pyrotechnic reefing line cutters and time delays.

U.S. Air Force Aeronautical Systems Division on Airdrop/aircraft equipment compatibility; textile material; emergency rescue personnel parachutes; aircraft vulnerability studies; navigation and avionics equipment performance, and developmental cargo aircraft.

National Aeronautics and Space Administration (NASA)/Marshall Space Flight Center on parachute escape systems, and shuttle/orbiter parachute landing systems.

U.S. Forest Service on statistical data relating to parachute service life.

Sandia National Laboratories on high speed parachute technology; computer simulations; trajectory analyses; logic/sequencing concepts and designs, and rocketry.

e. Natick also interacts with the NATO airborne community to share data, research, and technological findings, and to seek standardization when possible. Current British ram-air candidates are being tested for possible use in offset cargo deliveries.

f. Our interactions with industry and market surveillance are ongoing processes which are enhanced by the active participation of our official Natick representatives to many nongovernmental technical committees, and the active membership of Natick employees in national scientific and technical associations/societies such as the American Institute of Aeronautics and Astronautics (AIAA), the American Society of Mechanical Engineers (ASME) and others.

In addition, we formally interact with Industry during several key events in the R&D life cycle, e.g., at the time of formulation of the requirement document, when conducting a market analysis, during the preparation of specifications and standards, and the preparation of standardization program analyses/plans.

We are also active participants in the Independent R&D Program, the Army Information for Industry Program (including the Army Potential Contractor Program, the use of Broad Agency Announcements and Advanced Planning Briefings for Industry), the Unsolicited Proposals Program, and the Small Business Innovative Research Program.

g. We use the technical expertise available in the academic community. We participate in the Intergovernmental Personnel Act, and currently have two professors from the University of Lowell assigned to Natick to participate in research relating to soft landing technology and instrumentation techniques for measuring parachute openings. In addition, we interact with members of the academic community through participation in the AIAA technical committee for aerodynamic decelerators.

h. We also interface early in the RDTE process with various Training and Doctrine Command schools (e.g., the Quartermaster School, on rigging techniques and training requirements; the Infantry School, on personnel recovery systems) and maintain close coordination with these schools throughout the development process.

In addition, Natick has a full-time representative assigned to Fort Bragg, North Carolina, who is a focal point for user feedback for our fielded airdrop items.

APPENDIX

Airdrop Next Generation and Notional Systems

APPENDIX

Airdrop Next Generation and Notional Systems

Next Generation and Notional Systems

It is planned, that in the future, approximately 50 percent of our technology base resources (6.1 basic research, 6.2 exploratory development, and 6.3a proof-of-principle demonstration) will be allocated in support of specific Next Generation and Notional Systems (NG/NS). Next Generation Systems are the systems that will begin full-scale development in the 1990s and will provide a fielded capability into the 21st century. Notional Systems are capabilities that would potentially be developed in the early 21st century. For each system, the technological barriers have been identified which could prevent achievement of the capabilities desired. Programs and proof-of-principle demonstrations of prototypes (tech demos) have been structured in a logical, time-phased manner.

Next Generation Systems

300 Ft/250 Knot Personnel Airdrop System
Low Altitude RetroRocket Airdrop System

Notional System

Advanced Aerial Insertion System 2000

Title: 300 Ft/250 Knot Personnel Airdrop System

Relationship to NG/NS:

The 300 Ft/250 Knot Personnel Airdrop System is the next generation system for air delivering intact units of assault personnel on to the battlefield.

Description: The 300 Ft/250 Knot Personnel Airdrop System will provide the capability of air delivering squads of personnel in pods/capsules for mass assault. The system will utilize advanced extraction and soft landing systems to attain the full capability for mass assault at 250 knots airspeed and deployment at 300 feet altitude. The operational objective of the system is to provide for the cohesive landing of squads or special purpose teams, minimizing assembly time on the drop zone, and reducing troop dispersions. The pod can later be used as a shelter for the delivered unit.

Major Components:

The major components of the 300 Ft/250 Knot Personnel Airdrop System are:

- High speed parachute
- Durable, yet lightweight squad pod
- Soft landing system
- Advanced extraction system

Tech Barriers:

- Lightweight, sturdy personnel pod design
- Parachute system reliability

Status:

- Concept Evaluation
- Technical Demonstration Scheduled to begin in FY93

Technical POC: Robert Rodier/George Chakoian
Telephone 508-651-4738/4106

300 FT/250 Knot Personnel Airdrop System
Technical Barrier Descriptions

TITLE: Lightweight, sturdy personnel pod design.

DESCRIPTION: Personnel pod capable of withstanding loads associated with high speed extraction and ground impact on varied terrain. Pod reliability and personnel restraint and shock attenuation systems will be primary design drivers. Technologies required include pod designs, composite materials, automated fabrication techniques, and personnel restraint/shock attenuation systems.

TITLE: Parachute System Reliability

DESCRIPTION: Due to the low altitude (no reserve capability) and the fact that multiple personnel will need to rely on each system, the reliability of the parachute system will be the primary barrier to be overcome. Technologies that will be required include parachute extraction techniques and parachute system materials/designs that will withstand the high stresses of 250 knot extraction.

TITLE: Low Altitude RetroRocket Airdrop System (LARRS)

Relationship to NG/NS

The Low Altitude RetroRocket Airdrop System is the soft landing system that is the Next Generation System allowing soft landing of cargo and equipment.

DESCRIPTION: LARRS will provide airdrop of up to 60,000 pounds of equipment/supplies on multiple linked platforms at airspeeds up to 250 knots and altitudes as low as 300 feet. The system will utilize advanced parachute clusters for extraction and stabilization, and retrorockets for soft landing with impact velocity less than 8 feet per second, allowing roll-on/roll-off capability. High speed and low altitude will decrease vulnerability of the payload and the delivery aircraft, and provide increased drop zone accuracy. The payload system will be accommodated by the USAF developmental C-17 aircraft.

MAJOR COMPONENTS:

The major components of the LARRS are:

- 250 Knot high speed cargo parachute(s) with clustered deployment capability.
- Retrorocket motors, housing, sensors, and assembly system
- Linked platforms

TECH BARRIERS:

- Extraction of Linked Loads
- Stabilization of Heavy Linked Loads
- Deceleration for Soft Landing
- Soft Landing of Heavy Loads
- Automation of Control Functions

STATUS:

- Currently a 150 Knot LARRS is in Advanced Development (6.3B)
- 250 Knot, 60,000 Lb. LARRS Technical Demonstration Scheduled to begin in FY95

TECHNICAL POC: Henry Antkowiak
Telephone 508-651-5275

Low Altitude RetroRocket Airdrop System
Technical Barrier Descriptions

TITLE: Extraction of Linked Loads

DESCRIPTION: Extraction of a 60,000 pound linked platform airdrop load from 250 knots at 300 ft. Technologies that will be primarily required include parachute extraction techniques but will also consider other techniques. Parachute development will include materials/designs that will withstand the high stresses encountered at 250 knots with 60,000 lbs. Linked platform design/materials will need to withstand the high extraction loads, and the aircraft platform roller alignment system will have to accommodate high speed extraction.

TITLE: Stabilization of Heavy Linked Loads

DESCRIPTION: Stabilization of a 60,000 pound linked platform cargo airdrop load from 250 knots within 300 ft altitude. Initial research will assess the aerodynamic loading at 250 knots imposed on the extracted configuration and its tendency to destabilize. Technologies that will be required to provide stabilization will include a secondary parachute system, aerodynamic fin-like appendages for stabilization and payload shrouding to provide an aerodynamically clean surface to enhance stabilization in the presence of the severe high speed aircraft turbulent wake effects.

TITLE: Deceleration for Soft Landing

DESCRIPTION: Deceleration from 250 knots within 300 ft altitude to enable soft landing with minimal residual horizontal velocity. Technologies that will be required include parachute designing and materials selection, parachute cluster uniform opening techniques, and reefing and packing techniques. Deceleration techniques will be investigated that will minimize horizontal velocity/rotation prior to impacts.

TITLE: Soft Landing of Heavy Loads

DESCRIPTION: Soft landing of 60,000 pound linked platform airdrop load. Technologies that will be required will include linked platform retrorocket designs and alternative soft landing techniques such as airbags for asymmetrical platform landing to augment the retrorocket system. Platform designs/materials must withstand multiple landings at approximately 8 ft/s in all terrain conditions.

TITLE: Automation of Control Functions

DESCRIPTION: A computer control & sensing system for sensing motions during the extraction, stabilization, deceleration and soft landing phases of the drop and controlling the response devices that stabilize the particular phase. These motions may include accelerations and rotations which will be compared to desired values for purposes of initiating stability correction devices. Another function would be for ground sensing and retrorocket initiation prior to impact.

NG/NS TITLE: Advanced Aerial Insertion System 2000 (AAIS 2000)

Relationship to NG/NS

The Advanced Aerial Insertion System 2000 is the airdrop Notional System for delivery of a combined personnel/equipment payload at extremes of altitude and airspeed.

DESCRIPTION: The AAIS 2000 is an advanced aerial delivery system capable of ultra-high and very-low altitude insertion of 110,000 pounds of personnel and equipment delivered at airspeeds up to the cruising speed of cargo aircraft (400 knots). The system will deliver a complement of personnel in 12-person pods and heavy equipment on a common linked platform system. The high altitude capability will be from altitudes up to 50,000 feet utilizing a power-assisted gliding offset with automatic global navigation guidance and radar suppression characteristics. Low altitude capability will be at tree-top level utilizing power assisted extraction and stabilization. Both high and low altitude modes of operation will utilize a soft landing system to ensure impact velocities less than 8 feet per second and provide roll-on/roll-off capability. For high altitude delivery, the global positioning system on the platform will ensure drop zone accuracy, whereas drop zone accuracy for tree-top level delivery will be provided by the aircraft position system.

MAJOR COMPONENTS:

The major components of the AAIS 2000 are:

- Computer control and sensing system for extraction stabilization, deceleration, and soft landing phases.
- Soft landing components, to include air bag cushioning, retrorockets and alternative shock absorption means.
- Personnel Pod
- Common linked platform system
- Flexible fabric wing parachute and/or high speed cargo parachute

TECHNICAL BARRIERS:

- Extraction of Personnel and Equipment at Extreme Altitudes
- Stabilization of Personnel and Equipment
- Deceleration of Personnel and Equipment
- Soft Landing of Personnel and Equipment
- Automation of Control Functions

STATUS:

- Concept Evaluation
- Key Technical Demonstration of Combined Personnel/Equipment Low Altitude RetroRocket Airdrop in FY99

TECHNICAL POC: John Calligeros
Telephone: 508-651-4267

Advanced Aerial Insertion System 2000
Technical Barrier Descriptions

TITLE: Extraction of Personnel and Equipment

DESCRIPTION: Tree-top level and 50,000 ft. altitude extraction at the cruising speed of the aircraft (400 knots) of a 110,000 pound payload consisting of a complement of personnel and heavy equipment on a common linked platform system. Technologies required will include shock absorption techniques inherent in the personnel delivery pod to handle the high impulsive loading imposed by the sudden extraction force and procedures for protecting personnel under the subsequent turbulent wake loads at 400 knots. Additionally, technologies will include rocket, pyrotechnic, spring system and parachute extraction techniques appropriate for tree-top level as well as 50,000 ft. Tree-top level imposes added difficulty over 50,000 ft because of close proximity to ground resulting in more critical timing and extraction dynamics problems. Also, linked platform design/materials will need to withstand the high extraction loads.

TITLE: Stabilization of Personnel and Equipment

DESCRIPTION: Tree-top level and 50,000 ft altitude stabilization at the cruising speed of the aircraft (400 knots) of a 110,000 pound payload consisting of a complement of personnel and heavy equipment on a common linked platform system. Initial research will assess the aerodynamic loading at 400 knots imposed on the extracted cargo and personnel and the tendency of the system to destabilize. Technologies that will be required to provide stabilization will include thruster systems, payload shrouding to provide aerodynamically clean surface, and aerodynamic fin-like appendages for stabilization in the presence of the severe high speed aircraft turbulent wake effects at both tree-top and 50,000 ft. Tree-top stabilization also involves critical timing due to close proximity to the ground.

TITLE: Deceleration of Personnel and Equipment

DESCRIPTION: Deceleration from 400 knots from tree-top to enable soft landing with minimal residual horizontal velocity and from 50,000 ft to enable safe deployment of the offset delivery system. Deceleration technologies for tree-top will be required that will minimize horizontal velocity/rotation prior to impact, considering primarily thruster systems, but other technologies will also be required for both altitudes. Investigations will include personnel safety measure as part of the personnel pod that offset the high deceleration loads during deceleration. The personnel pod will also incorporate means for safe escape during an aborted deceleration phase, emphasizing ejection methods.

TITLE: Soft Landing of Personnel and Equipment

DESCRIPTION: Soft landing of 110,000 pound linked platform airdrop loads being decelerated to virtually zero horizontal velocity and loads being delivered by offset means. Technologies required will include shock absorption techniques inherent in the personnel delivery pod to handle the high deceleration loading imposed by the soft landing system. Technologies will include retrorockets for vertical descent delivery and flared flexible fabric wings for offset delivery. Additionally, provisions will be made for some appreciable forward velocity at impact.

TITLE: Power-Assisted Offset Delivery

DESCRIPTION: Offset delivery of 110,000 pound linked platform airdrop load utilizing automatic global navigation and control and power assist to increase offset range. Technologies required will include direct deployment of the system from the aircraft versus separate extraction and delivery parachutes, and means of reducing large opening loads for a 110,000 flexible fabric wing parachute. Also, optimum aerodynamic platform/airfoil cross-section, materials of construction, and packing and reefing techniques for the most efficient aerodynamic offset system. Additionally, lightweight quiet thrust sources to provide power assist for greater offset range will be required, such as propellers, rockets, and turbines. Control system will consider use of parachute versus rudder steering.

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